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A VIDEO BASED SYSTEM AND METHOD FOR IMPROVING AIRCRAFT SECURITY

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2004 SPIE Defense & Security Symposium
Enhanced and Synthetic Vision

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE
12 APR 2004

2. REPORT TYPE
N/A

3. DATES COVERED

4. TITLE AND SUBTITLE
A Video Based System and Method for Improving Aircraft Security

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
; ; ; ; Meitzler /TomEberstine /SamSmith /GregRodin /YelenaZorka /Nick

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000

8. PERFORMING ORGANIZATION REPORT NUMBER
18582

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
TACOM TARDEC

10. SPONSOR/MONITOR’S ACRONYM(S)

11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**26**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

CAPA Security Recommendations

- In late September of 2001 the Commercial Airline Pilots Association (CAPA) endorsed president Bush's plan for improved airline security but expressed concern that it did not address many critical issues.
- The 26,000 pilots represented by the member unions of CAPA studied the possibility of many additional security options for the airline industry. First among their recommendations were the following:

  1. Adopt new measures to reinforce the cockpit and aircraft.
  2. Develop a reinforced cabin/cockpit bulkhead and door.
  3. Redesign and modernize the door lock using the latest technology.
  4. Install video surveillance cameras in the cabin so that pilots and personnel on the ground can monitor passenger cabin activity.
  5. Modify the cabin interphone using "videophone" technology
  6. Modify all transport category aircraft with an air-ground switch that automatically turns the aircraft radar transponder "on" when the aircraft main landing gear are not on the ground.

A Cabin Security System

- The authors address the video surveillance option utilizing multiple fixed cameras and powerful image processing to provide the crew with a complete seat-by- seat view of what is occurring within the passenger cabin.

- The system could also be linked to FBI known terrorist databases that could be accessed to determine the identity of any passenger from a camera image. Imagery from the aircraft could also be transmitted to the ground for further processing or transmitted to aircraft responding to an emergency to allow confirmation of the nature of the emergency.

- The system would usually be controlled from the cockpit, but if necessary could be overridden by ground controllers.

A Cabin Security System

- If the crew suspected that the security of an aircraft had been compromised it would be critical for a crew member to be able to clearly and rapidly see what is occurring inside the passenger cabin without having to open the door to the cockpit.

- In case of emergency it would also be extremely valuable for ground personnel and aircraft responding to the emergency to be able to visually monitor what is happening inside the aircraft cabin

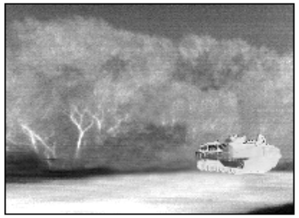
Army application of the system
360 Degree Fusion for Situational Awareness

We propose a “see-through vehicle visualization” system for use in military ground vehicles that will provide real-time situational awareness of the area immediately around the vehicle. The crew is provided with a real-time, close-in, seamless panoramic view 360 degrees around the vehicle and can pan or zoom the view-port to any aspect of the panorama. This will allow the crew or squad to detect close-in threats or determine situational awareness prior to vehicle egress in hostile environments. The system can provide both visual and infrared imagery independently or fuse them in combination. Ford and TARDEC have begun testing this system for commercial and military applications.

Visible image

+

IR image



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VISIBLE + IR FUSED

Fusion of Infrared and Visual Images

But only infrared image fused with visible light image show all features

Visible image shows:

- other vehicles
- blinker, break lights
- lane markings
- signs

Infrared image shows:

- other vehicles
- persons and animals
- road beyond headlights

Panoramic Sensor Fusion Vehicle

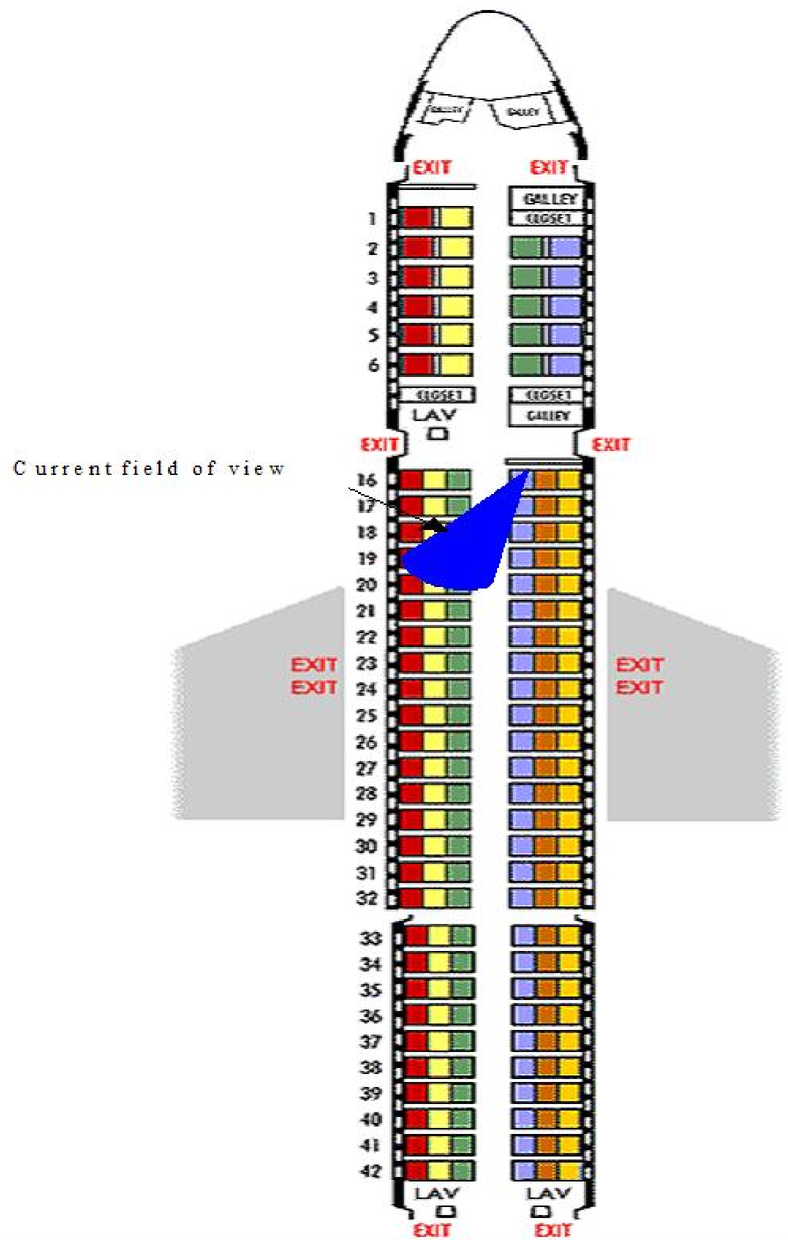
- Concept vehicle for homeland defense.
- 360 wrap around real-time infrared and visual sensor fusion.
- Situational awareness and crowd surveillance.
- Recording of scenes for later review.

Sensors mounted in grill of Lincoln Navigator

Camera System on Lincoln Navigator

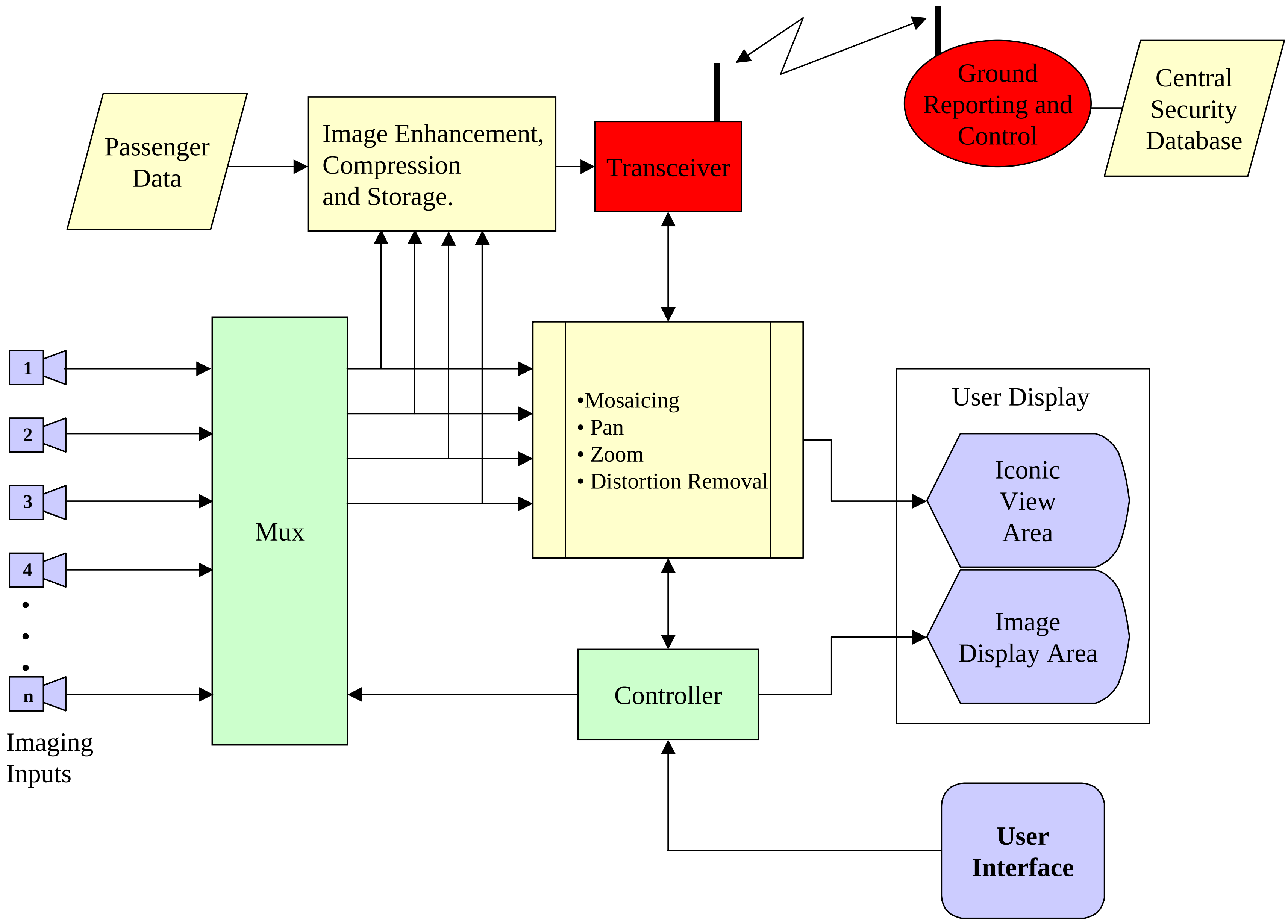
Front and rear camera assemblies mounted on a Lincoln Navigator test vehicle

Camera FOV in the aircraft cabin system



The figure shows the field of view of one of the proposed cameras in this system.

Components of the System



Components of the proposed security system

- Small cameras that collect images of the cabin interior placed throughout the passenger cabin.
- Near IR illuminators so that the system will be operational even when the cabin lights are dimmed, or use of passive IR cameras.
- An image processing system that will acquire images from multiple cameras and mosaic the images to provide an operator controllable view of the entire cabin interior.
- An image enhancement system capable of building very high-resolution images from multiple frames of video imagery.
- A database that contains information about all the passengers on the flight, including, name, seat location, when the ticket was purchased, etc.
- A user interface to control the image processing system and the database inquiries.
- A control computer to coordinate the various components of the system.
- A display to view the images, icons that convey the current view direction and location and textual information about subjects included in the view.
- A receive/transmitter capable of transmitting imagery to the ground and/or other aircraft and receiving information or control commands from the ground and/or other aircraft.
- A central security database that can be interrogated using imagery from the aircraft.
- A video multiplexer to route the required camera outputs to image processing and enhancement functions.

System Features

- 1. Covert System - The system would be covert, in that it would use multiple hidden miniature cameras that are fixed in position.
- The ability to provide an operator with the various views would be accomplished by computer processing the images from several cameras at once, rather than mechanically panning and zooming a single camera. The system would automatically shift from camera to camera when necessary to broaden or change video coverage.
- The cameras used would be sensitive to near IR and the system would include IR illuminators for use in darkness. Alternatively, we may want to use a passive system, since there may be a legal issue of irradiating people.

System Features

- 2. Know the exact location of the area in view.
- It is sometimes difficult to maintain situational orientation while panning, zooming and "flying" within a virtual image. To alleviate this problem, an iconic representation of the area being viewed within the aircraft (see Fig. XX) could be displayed simultaneously or alternatively by user selection to maintain the viewer's orientation.
- The video representation could also indicate the row number and seat location of the view. The passenger name and other information from a local or remote database could also be displayed as a pull-down menu pick on any image.

System Features

- 3. The system could be used for passenger identification.

  The system would use multiple video images from one or more cameras to build a high-resolution image of any passenger. It could be trained by using neural networks or fuzzy logic to look for distinguishing features that would positively identify the subject.
- These images would be available to the aircraft crew and could be used for comparison to a database in the airplane or on the ground.
- Other biometric techniques such as face or iris identification may be included either on board or through processing images on the ground to automate positive identification.

System Features

- 4. Information available to other aircraft and ground personnel in case of an emergency.
- The system could be controlled from the cockpit or from an external location such as the ground or another aircraft. Ground control could transparently request imagery independent of the aircraft control if cockpit control had been compromised.
- Under non-emergency situations compressed images could be transmitted slowly. Even at low rates, a very detailed high-resolution view of the entire interior of the aircraft could be transmitted in a few minutes.
- Under emergency situations, real-time imagery from multiple cameras could be sent to the ground continuously. Such visual confirmation would greatly help ground controllers and intercepting aircraft quickly make the correct decision in these fast moving and dangerous situations.

System Components

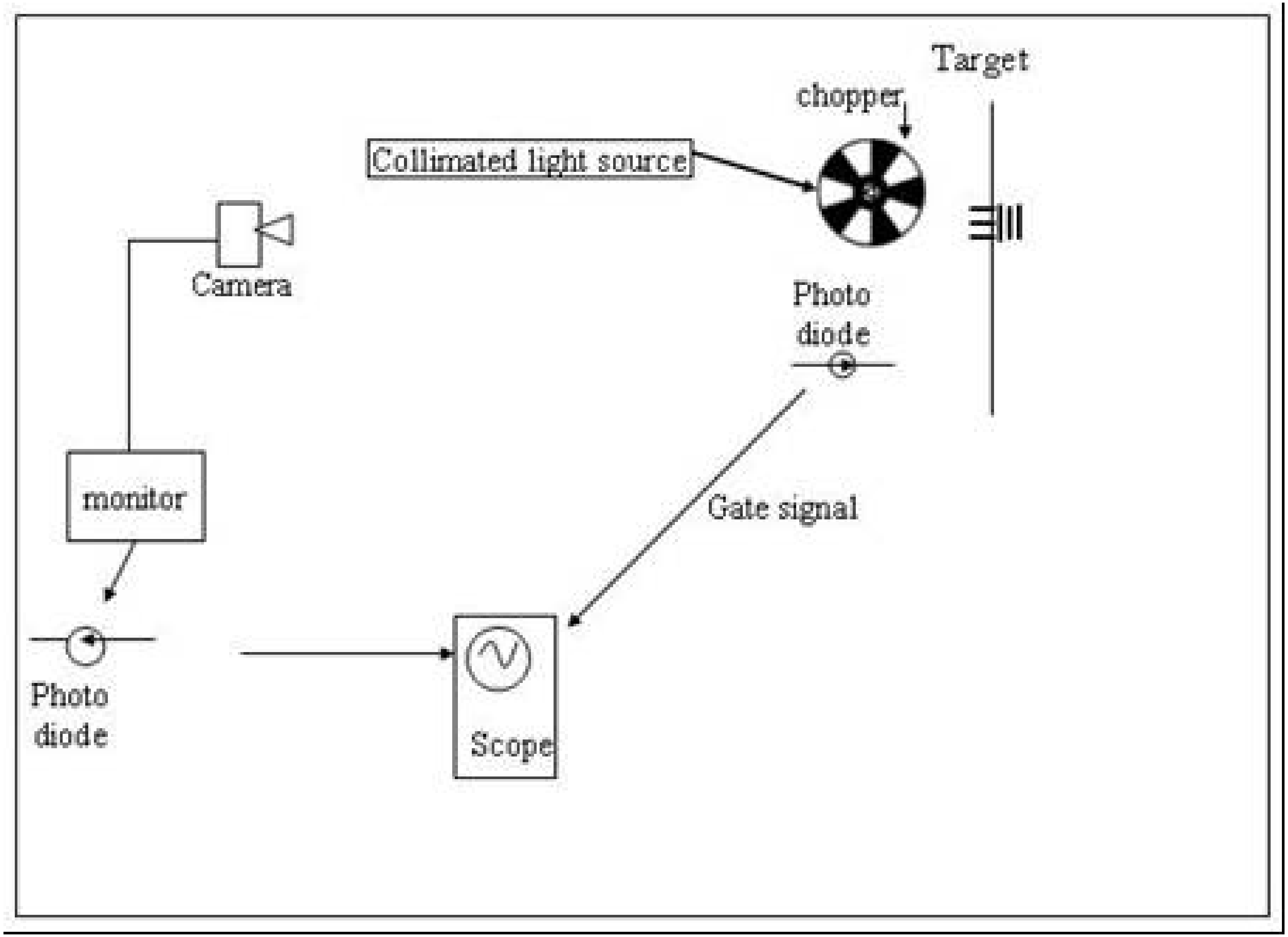
Elmo QN42 Camera

- Elmo QN42 visual cameras have a small size and excellent color fidelity.
- Field of view of approximately 53 degrees by 39 degrees.
- The Elmo cameras have a 410,000 pixel color CCD that results in 786 (V) by 470 lines (H) resolution with simultaneous Y/C and composite video outputs.

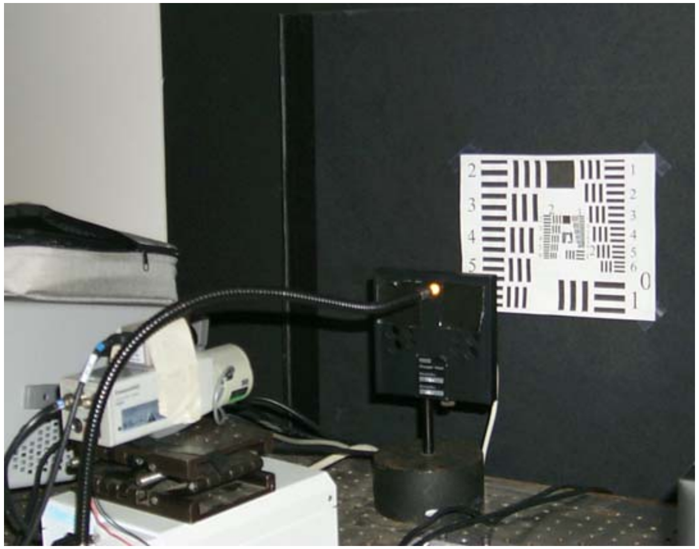
Indigo Omega IR camera

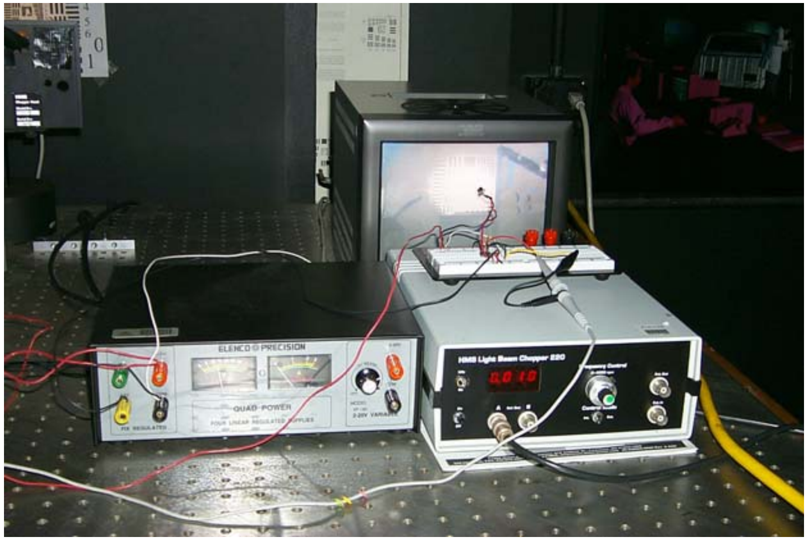
- Indigo Omega infrared cameras were selected because of their small size and clear image.
- The detectors are uncooled microbolometers.
- Image array resolution of 160 by 120 pixels.
- Pixel size is 51 by 51 microns.
- The infrared cameras are fitted with 8.5 mm lenses that provide a field of view of approximately 55 by 40 degrees.
- The Indigo Omega cameras are sensitive to the 7.5 to 13.5 micron band of the EM spectrum.

Apparatus for Measuring Time Response of Cameras



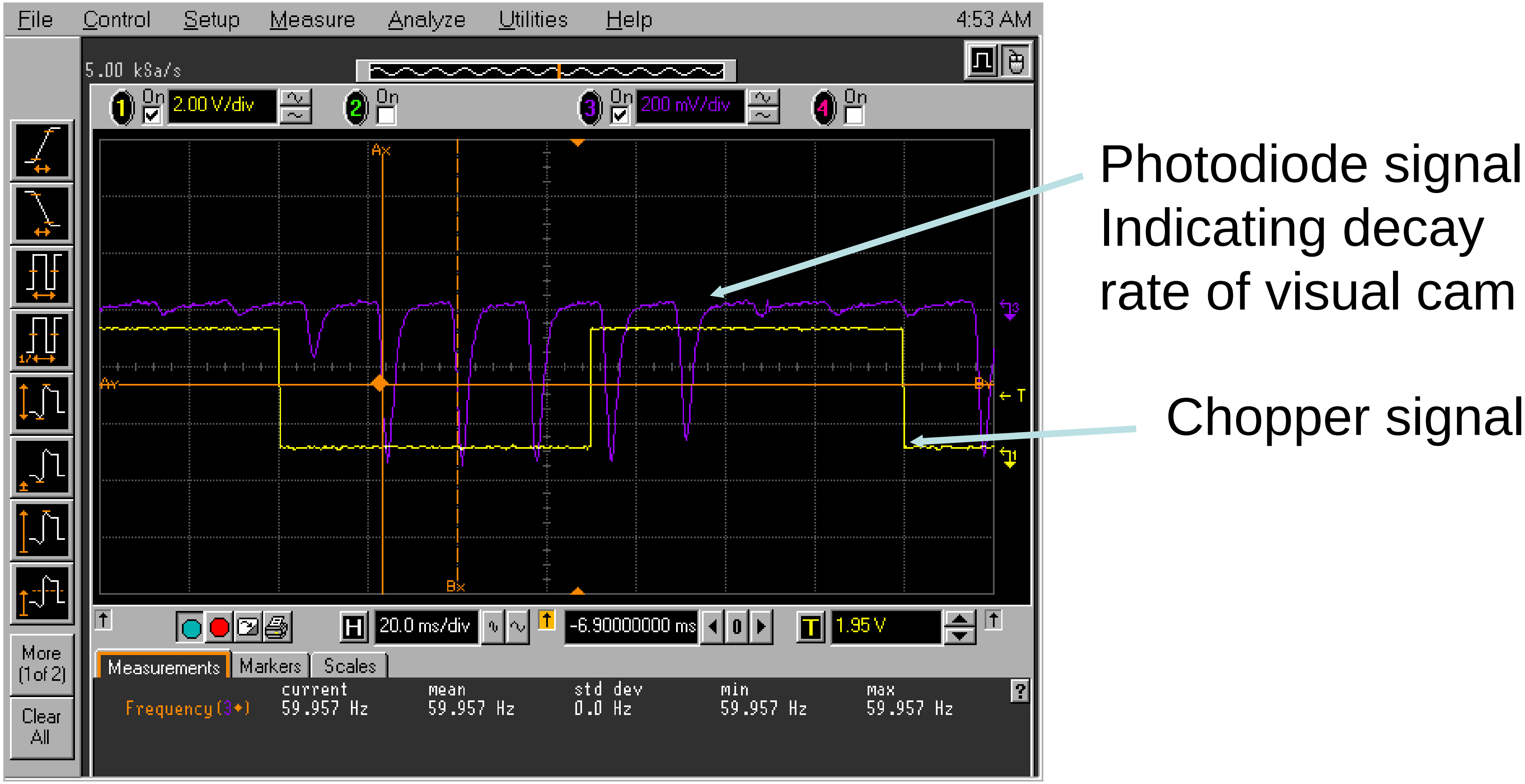
Experimental Apparatus





Chopper wheel and light source (left) and photo detector circuit and display (right)

Oscilloscope Display for Visual Camera



The period of the chopper reference trace is 7 divisions, which at 20msec/div is a period of 140msec or a frequency of 7 Hz. Taking the average location of the response signal of the photodiode to be at the center of the three sine waves, the average is at approximately 2.5 seconds after the beginning of the chopper signal, which 20 msec/div means a response time of 40 msec.

Camera Gain Test Method

- Cameras for military and surveillance use need to provide high contrast under both low light and high glare conditions.
- Most low light cameras perform well when the entire scene is dark, but, provide almost no contrast if there is a bright object in the scene.
- Even if the camera doesn't bloom, this lack of contrast makes the cameras unsuitable for low light surveillance applications.
- The authors have developed a testing procedure to rank the performance of visual cameras.

Experimental Method for Dynamic Range Test

- A series of tests were performed on three of the original test cameras using two resolution targets illuminated at different light levels.
- Varying the incident light level in detectability increments created a detailed characterization curve of these cameras. The light level was measured at the target with a photometer. See the following figures for the experimental setup.
- The targets were displayed in “cubby holes” one meter on a side which allowed dramatically different light levels to be used on the targets. The targets were illuminated by 150-watt spotlights whose brightness could be changed by the use of individual variable transformers.
- The distance from the tested camera to the target was adjusted to achieve the scene shown on the monitor.

Experimental Method for Dynamic Range Test cont.

Image of bar targets seen under
normal lighting

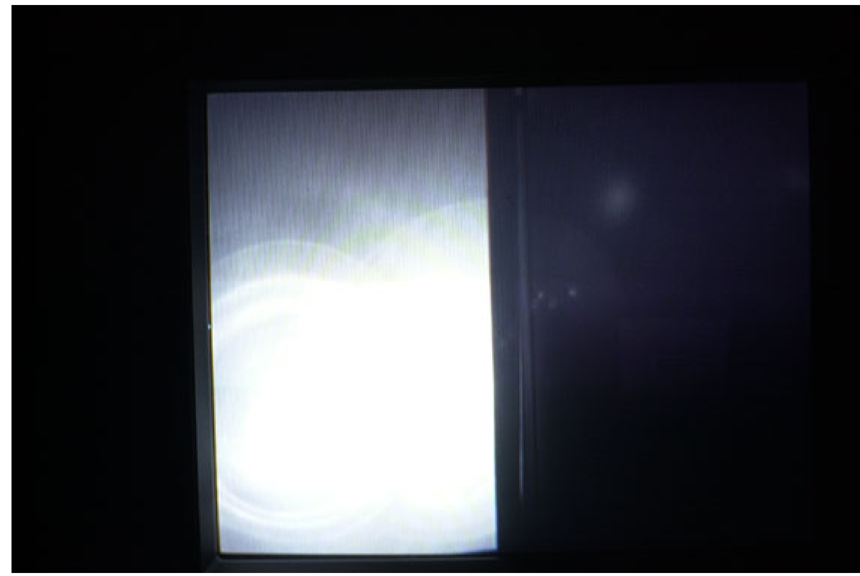
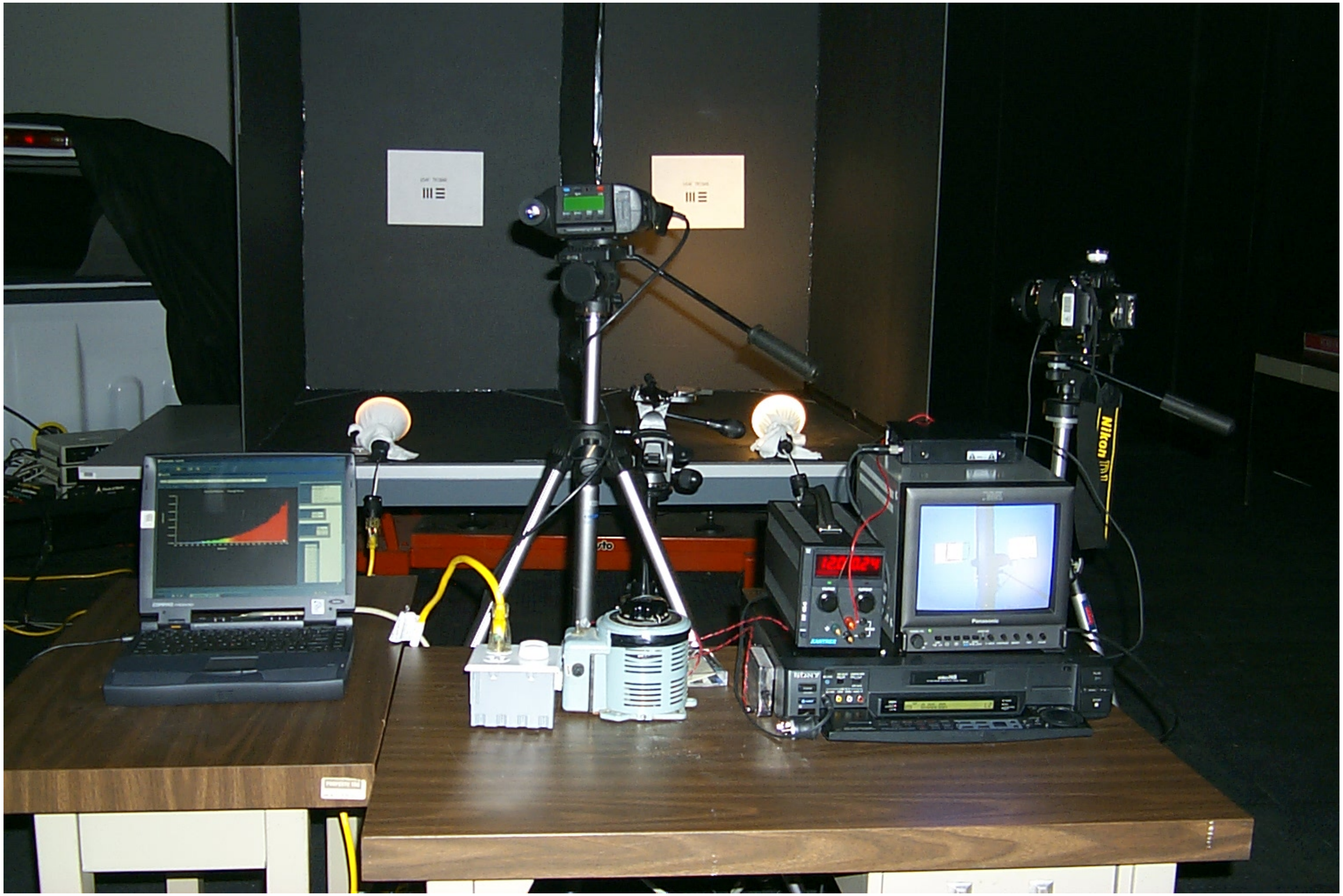


Image of bar targets from monitor
and camera under wide luminance range

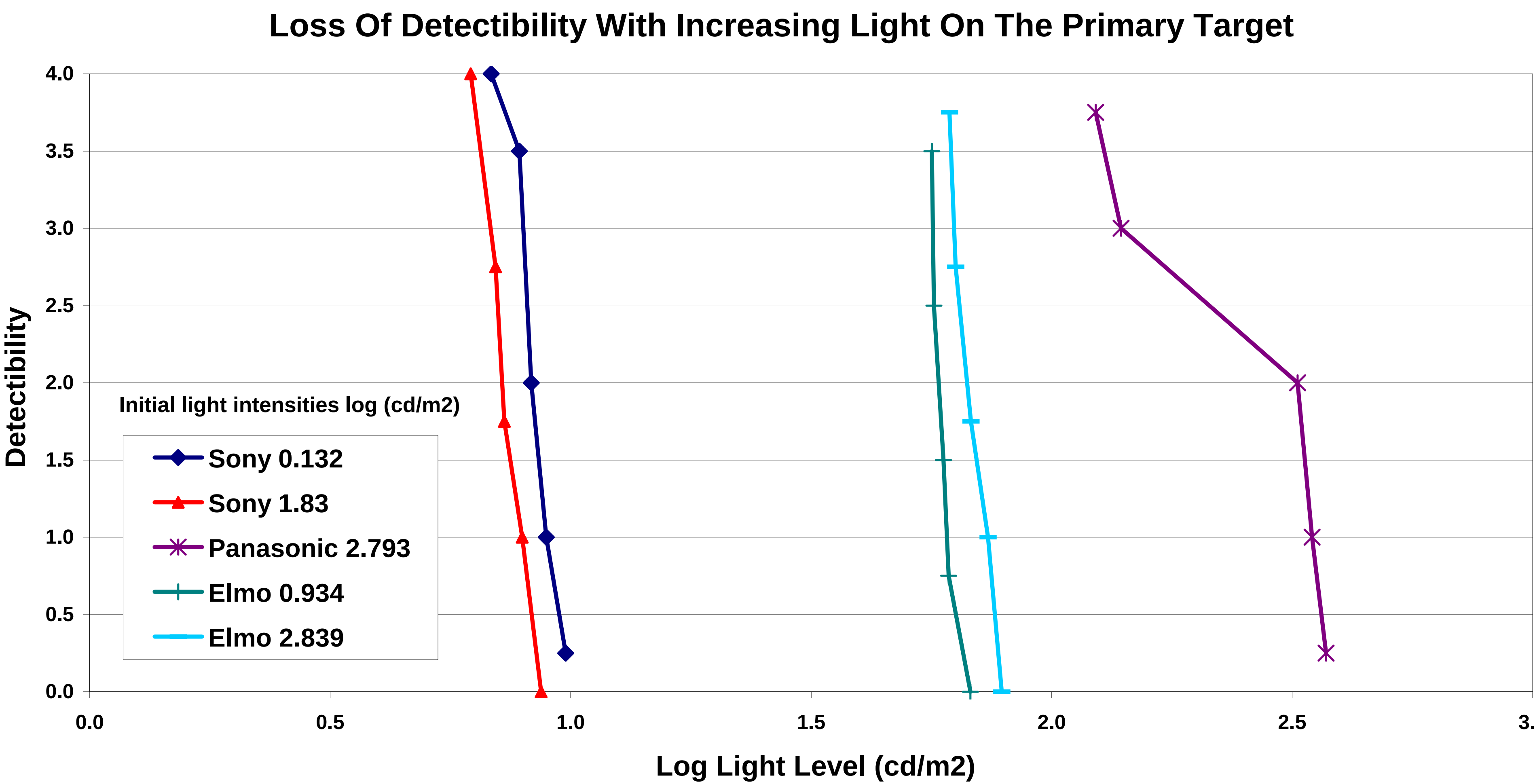
Experimental Apparatus for Dynamic Range Test



Procedure for Dynamic Range Test cont

- The tests began with both targets illuminated at a level just sufficient to allow resolution of both targets.
- The light level on the left target was held constant during the experiment while the light on the right target was increased until the resolution degraded.
- Progressive degradation as the light level at the target was increased was reported by the 4 observers and recorded using the same 0 to 4 scale used in the previous experiments. The light levels at that target were recorded when a transition in detectability was reported by a majority of observers.
- This test yielded a relationship between detectability and light level as the illumination on the target is increased beyond the optimum level. This relationship is important for military surveillance applications since it is rarely possible to achieve any control over scene lighting much less achieve optimal conditions.

Results of Dynamic Range Test



The imaging performance of the 3 cameras under 5 incident light intensities separated in to three sensitivity regimes.

Future Work

- Test cabin surveillance configuration on a bus.
- Compare the response times of several types of IR, visual cameras and displays combinations, i.e. LCD or flexible displays.
- Measure the gain capabilities of the cameras.